AD-A137 807 SUPERPLASTIC BONDING AND ULTRAHIGH CARBON STEEL LAMINATED COMPOSITES..(U) STANFORD UNIV CA DEPT OF MATERIALS SCIENCE AND ENGINEERING O D SHERBY ET AL. 1/1

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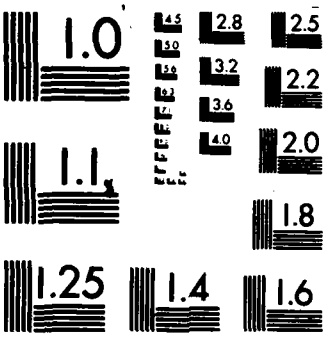

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The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation

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laminated composites, metal matrix composites, superplasticity, impact properties, ultrahigh carbon steels, ultrafine grains, selective heat treatment, diffusion.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Ferrous laminated composites based on ultrahigh carbon (UHC) steel have been successfully manufactured by rolling bonding below the A_1 transition temperature. This procedure results in the development of sharp and discrete layer boundaries since no interdiffusion occurs during rolling. Good bonding is achieved because of the presence of ultrafine grains in the UHC steel. Mechanical properties of the composites have been evaluated for their charpy V-notch impact properties and for their superplastic characteristics. An extremely low ductile-to-brittle transition temperature of ~~-150~~°C, and very high shelf energies (≥325 J), have been found both

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for ferrous laminated composites and for UHC steel laminates. This remarkably good behavior is shown to be a result of notch blunting within the laminates as a result of delamination. If the interlayer strength is improved by heat treatment, delamination does not take place and the impact properties are degraded. The mechanical properties of a ferrous laminated composite consisting of alternating layers of a superplastic UHC steel and non-superplastic I.F. iron, have been studied at intermediate temperatures (600-725°C). Superplastic behavior was approached in the laminated composite with values of the strain rate sensitivity exponent of as high as 0.3 measured and maximum tensile elongation of 430% achieved.

SUPERPLASTIC BONDING AND ULTRAHIGH CARBON STEEL LAMINATED COMPOSITES

(DAAG-29-79-C-0190)

FINAL REPORT (September 1979 - September 1983)

by

Oleg D. Sherby, Dong Wha Kum, Jeffrey Wadsworth and Barry C. Snyder

This Final Report summarizes the work accomplished during the period September 1979 to September 1983 on the program "Superplastic Bonding and Ultrahigh Carbon Steel Laminated Composites". The program was sponsored by the Army Research Office under Contract DAAG-29-79-C-0190. The project monitor was Dr. George Mayer. The authors would like to express their appreciation to Dr. Mayer for his encouragement and cooperation throughout the course of the program. This technical interest in our work, as well as his guidance, helped to optimize our research work toward understanding the mechanical behavior of ferrous laminated composites. In addition, we give thanks to Dr. John Bailey, who served as project monitor, together with Dr. Mayer, during the last year of the program, and whose help and cooperation is gratefully acknowledged.

A summary of the work performed on this program is well documented in the eight progress reports submitted during the course of this investigation. The following outlines our accomplishments.

1. Statement of the Problem Studied

The two principal objectives of the ARO program were: (1) synthesis and preparation of ferrous base laminated composites based on ultrahigh carbon (UHC) steel and (2) study of the mechanical behavior of these ferrous laminated composites.

2. Summary of the Most Important Results

Ferrous laminated composites based on ultrahigh carbon (UHC) steel have been successfully manufactured by rolling bonding below the A_1 transition temperature. This procedure results in the development of sharp and discrete layer boundaries since no interdiffusion occurs during rolling. Good bonding is achieved because of the presence of ultrafine grains in the UHC steel. Mechanical properties of the composites have been evaluated for their Charpy V-notch impact properties and for their superplastic characteristics. An extremely low ductile-to-brittle transition temperature of -150°C, and very high shelf energies (> 325 J), have been found both

for ferrous laminated composites and for UHC steel laminates. This remarkably good behavior is shown to be a result of notch blunting within the laminates as a result of delamination. If the interlayer strength is improved by heat treatment, delamination does not take place and the impact properties are degraded. The mechanical properties of a ferrous laminated composite consisting of alternating layers of a superplastic UHC steel and non-superplastic I.F. iron, have been studied at intermediate temperatures (600-725°C). Superplastic behavior was approached in the laminated composite with values of the strain rate sensitivity exponent of as high as 0.3 measured and maximum tensile elongation of 430% achieved.

3. List of Publications, Theses and Presentations on Technical Program

A. Publications

(1) "The Impact Properties of Laminated Composites Containing Ultrahigh (UHC) Steels", D. W. Kum, T. Oyama, J. Wadsworth and Oleg D. Sherby, J. Mechanics and Physics of Solids, 31, 1983, 173-186.

(2) "Superplastic Behavior in Ferrous Laminated Composites", B. C. Snyder, J. Wadsworth and O. D. Sherby, in press, Acta Metallurgica, 1984.

B. Theses

(1) "Impact Characteristics of Ultrahigh Carbon (UHC) Steels and a UHC Steel/Mild Steel Laminated Composite", by Yukio Itoh, Engineer's Degree, June 1980.

(2) "Superplasticity in Ferrous Laminated Composites", by Barry C. Snyder, Ph.D. degree, June 1982.

C. Presentations

(1) Seminar on mechanical properties of ferrous laminated composites based on UHC steel, Stanford University, 24 February 1981. Presentations were given by Messrs. B. Snyder, D. W. Kum, W. Moberly, J. Wadsworth and O. D. Sherby.

(2) Seminar on mechanical properties of ferrous laminated composites based on UHC steel, Stanford University, 19 February 1982. Presentations were given by Messrs. B. C. Snyder, J. Wadsworth and D. W. Kum.

(3) "Ultrahigh Carbon (UHC) Steels and Ferrous Laminated Composites Based on UHC Steel", Seminar by Oleg D. Sherby, AMMRC, Watertown, Massachusetts, 29 October 1982.

(4) "Mechanical Behavior of Laminated Composites Based on Ultrahigh Carbon (UHC) Steel", Seminar by Oleg D. Sherby, Army Research Office, Durham, N. C., 1 November 1982.

(5) "Mechanical Behavior of Ferrous Laminated Composites Based on Ultrahigh Carbon (UHC) Steel", by D. W. Kum, Golden Gate Welding and Metal Congress, San Francisco, California, 9 February 1983.

(6) Seminar on mechanical behavior of ferrous laminated composites based on ultrahigh carbon (UHC) steel, Stanford University, 15 February 1983. Presentations were given by O. D. Sherby, D. W. Kum, J. Wadsworth and O. A. Ruano.

(7) "Impact Behavior of Ferrous Laminated Composites Based on Ultrahigh Carbon (UHC) Steel", by Oleg D. Sherby, Lawrence Livermore National Laboratory, Livermore, California, 3 March 1983.

(8) "Ultrahigh Carbon (UHC) Steels and Ferrous Laminated Composites Based on UHC Steel", by Oleg D. Sherby, TAKOM Headquarters, Warren, Michigan, 11 April 1983.

(9) "Ferrous Laminated Composites Based on Ultrahigh Carbon (UHC) Steel", by Dong Wha Kum, Industrial Affiliates Meeting, Department of Materials Science and Engineering, Stanford University, 2 May 1983.

4. List of all Participating Personnel and Degrees Received

Professionals

Dr. Oleg D. Sherby, Principal Investigator and Professor
Dr. Jeffrey Wadsworth, Consulting Assistant Professor
Dr. George Frommeyer, German Visiting Scholar (no salary)

Graduate Research Assistants

Yukio Itoh, Engineer's Degree, June 1980

Dong Wha Kum, M. S. Degree, June 1980

Warren Moberly, M. S. Candidate

Barry L. Snyder, Ph.D. Degree, June 1982

Shyong Lee, Engineer's Degree Candidate


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